APPENDIX B: OVERVIEW OF GAS DISPATCH MODEL

OVERVIEW

Our analyses are designed to evaluate the *physical* ability of the electric and gas systems to simultaneously meet their daily demands. For the gas industry, there are three distinct "capacities" that are important – contract firm capacity, physical capacity and takeaway capacity -- and each has implications for what may happen at a delivery point.

- The most common "capacity" reference is the **contractual firm capacity** of a pipeline. This is the volume that the pipeline has committed to deliver to a customer by virtue of a financially binding agreement. In the past, where long-term contracts dominated and the pipeline was limited to only building the capacity that customers had agreed to pay for, the contractual capacity and the physical capacity of a pipeline were often the same. With the advent of capacity pipeline restructuring, many customers have not renewed expiring contracts, thereby creating a spread between the physical and contractual capacity of a pipeline. In addition, pipelines have occasionally built expansions without contractual commitments for the entire volume and assumed the market risk of recovering their costs. In general, contractual capacity is less than the physical capacity of a pipeline.

- The second most common "capacity" reference is to the **physical capacity** of a pipeline. This refers to the maximum amount of gas that can flow through any point given the size of the pipe, the ambient temperature and the maximum allowable pressure. While this term is widely used, it is often misinterpreted, since it varies with the actual pressure at a point. The pressure at a point can change as a result of what happens at another point in the pipeline system. For example, if a customer upstream of a given delivery point takes more gas, then the pressure at the downstream point will have declined and the pipeline's ability to deliver at the downstream point will be diminished. Conversely, early in the day, a pipeline may have increased their pressure and created some 'line pack' that would allow a customer to take more than they generally could at any given point. Any expectation that one could rely on these additional volumes without benefit of a contract may be questionable. Pipelines make day-ahead and hourly choices regarding what pressure they need to operate their pipe at, anticipating issues such as the volume requested by customers and temperature that may impose additional demands on the pipeline.

- The customer also imposes a limit on the volumes that may be delivered at a point known as the "**take-away capacity**." This is the maximum volume that the customer may receive at a point and it too is a variable, conditioned by the demand at that point. For example, a power plant near a pipeline/LDC city-gate may increase the delivery capacity of the station by virtue of its reducing the pressure on the receipt side of the point, thereby allowing more gas to flow.

Our analysis was based, in part, on the normal daily physical capacity of each pipeline. However, this is not the only "physical" capacity in the delivery network. Each of the capacities discussed above were addressed in our model design. Both the physical capacities along each pipeline and the take-away capacities at each delivery point to the LDCs have been assessed and included in the model. Where physical capacities exceed contracted volumes, the model was designed such that gas will preferentially flow at the contracted level. For example, if two pipelines serve an LDC, and pipeline A has physical capacity above its contracted capacity, the excess will not be utilized until pipeline B's contracted volumes have been filled. The limiting "constraint" at any point cannot be determined *ex ante*. Rather it must be determined within the context of the total system operations at each that point in time.

We have not addressed the price/cost implications of various outcomes to assess whether market participants would choose to pay for the gas deliveries. We have assumed that gas deliveries would be made if the physical delivery capacity existed, since the objective of our analysis was to assess the adequacy of the pipeline/LDC infrastructure. Given that the pipeline industry is based on a *contract carriage* paradigm, it is very important to understand that, absent commitments by customers to contract for new pipeline capacity, the physical flows we have characterized might not be realized in the market. While we have based our analysis on the physical capability of the pipeline industry to deliver the market volumes, there are several policy implications that may need to be addressed to deal with this distinction.

The gas model developed for this project is based on a network model (a variation on GRIDNET) that solves over a series of nodes (storage facilities, supply sources, demand sinks, pipeline interconnects) and arcs (pipelines) such that gas demand is met by supplies in an economically efficient manner. It does this through the use of EMNET, a linear programming algorithm that optimizes the gas pipeline system to maximize profit. The basic model has been modified in two significant ways to focus on New York State – first; we have represented the infrastructure and delivery systems within the state in great detail. Secondly, the model's aim has been changed from focusing on price differentials between market points to examine the feasibility of flow patterns. The model operates on a daily basis.

DATA SOURCES

In order to assure the quality of the model, a variety of sources have been used to obtain and verify data. Data were requested from pipelines, LDCs and federal and state government agencies as well as acquired from commercial vendors.

- Pipelines were asked to provide capacity data at the New York border, interconnects with other pipelines, interconnects with LDCs, and at other points along their systems (compressor stations, meter stations, or other points that may constrain the flows along the pipe).

- While most pipelines have complied with these requests. some have not—in these cases border capacities have been estimated using publicly available data from the Energy Information Administration's (EIA) "Natural Gas Pipeline State Border Capacity Database."

- LDCs have also contributed data regarding their off-take capacity from pipelines. Wherever possible, each interconnect has two volumes associated with it—a delivery capacity supplied by the pipeline, and a receipt capacity supplied by the LDC.

- The LDCs have also supplied data regarding storage contracts and usage patterns. These data include minimum and maximum inventory levels, maximum injection and withdrawal rates, must turn volumes, the geographic location of the storage fields behind the contracts, and the pipelines associated with the storage fields and contracts.

- Each LDC has also given information on expected demand volumes by category, over time and temperature variation. Demand categories include both firm and non-firm sales and transportation gas. Demand data are discussed in greater detail below.

INPUTS

Other than the physical attributes of the pipeline systems (interconnections, capacity, links, storage, etc.), the primary inputs to the model are the supply and demand parameters.

Demand

- Each LDC has provided estimates of their demand for non-power related gas for each year of the study. This includes firm sales gas, firm transportation gas, non-firm sales gas, and non-firm transportation gas. In addition, they have supplied us with normal-weather degree-day data, and we have broken out each demand category into "base" demand and temperature-sensitive demand.

- Power-related demand for fuel by each generating unit is provided by CRA's MAPS model of New York State's electricity grid. Since generating units have different abilities to burn gas and/or oil, we group the units in terms of their ability to substitute oil for gas:

    Gas consumed by gas-only units, which includes both steam units taking gas at low pressures and some simple and combined cycle turbines that take gas high pressures. There is no ability for fuel switching at these units. Hence, if gas is unavailable to these units they will not operate and electricity demands will need to be met by other generating units.

Fuel (either gas or oil) consumed by dual-fuel steam units. If gas is unavailable at these plants, their demand for fuel can be met by substituting oil in place of gas, and therefore will not represent a problem for the electricity grid.

Fuel (either gas or oil) consumed by simple and combined cycle turbines that predominantly burn gas, but have some oil backup capability.

The total demand for fuel by gas capable units represents the maximum potential gas demand for electric generation. The maximum total gas demand is fed into the gas model to determine that portion of the demand receiving gas (since gas is assumed to be the preferred fuel) and, if gas supplies are insufficient, that portion of the total demand using oil.

- Each demand category is associated with a different price—the highest priced demand is served first, and the lowest price last. This allows us to assign relative priority in meeting demand. For example, residential customers will be served before generating units, and combined cycles will be served before steam gas units, since their efficiency advantage, generally makes them more profitable to serve.

  Several pipelines pass through NY and into New England states. The volumes for downstream markets were developed using data from the pipelines when they provided the data. In other instances, flows into New England have been estimated from the EIA's "Natural Gas Pipeline State Border Capacity Database."

Supply

- Supply is broken out into New York production, firm supply, storage withdrawals, and spot supply.

  New York production and firm supply are assigned the lowest cost, and therefore will flow first.

  Storage withdrawals have the next highest cost, and therefore meet the next level of gas demand.

  Spot supplies are the highest cost, and therefore are only drawn when the other three categories have been exhausted.

- Firm supplies are allocated to each pipeline relative to the firm contracted volumes that each LDC holds. The sum of the firm supplies into the state is equal to the sum of the peak-day firm supplies of the LDCs.

Spot supplies are limited by each pipeline's available unused daily capacity, and can flow to meet any demand, given that the pipeline capacity is available to move gas to the customer. We can make this key assumption because the project and this model are designed to test the robustness of the New York State pipeline infrastructure, not the overall productivity of the North American supply basins.

- Three pipeline capacity expansions were included as part of the base analysis. Details on the Athens expansion, Iroquois Eastchester and that portion of the Transco MarketLink Phase II that serves New York can be found in the "Pipeline Capacity Additions in the Base Case" section of this report.

OUTPUTS

While there are numerous outputs of the model, the following is a list of some of the more important ones for this study:

- Flow and capacity at each node.
- Customer receipts from each pipeline, and for each demand category.
- Supply types to pipelines (firm, spot, NY production, or storage).
- Storage use patterns (injections, withdrawals, and resulting inventory levels)
- Flows at interconnections between pipelines.

The resulting mix of gas and oil usage is of particular interest to NYSERDA/NYISO. In addition to characterizing the resulting fuel mix (*e.g.*, the amount of gas burn, the amount of oil burn, the number of days of oil burn, etc.) our analysis allows us to characterize the gas system's ability to meet the total potential demand for gas by electric generators. Again, we characterize the number of days that the gas system can not meet the maximum potential demand for gas and the amount of oil that must be burned (somewhere in the electric system) to produce substitute generation.

NEW YORK GAS SYSTEM STRUCTURE

The LDCs included in the study are listed by region in Table B1, below.

Table B1

New York State Gas Distribution Companies by Region (As of January 1, 2002)

Downstate LDCs	Upstate LDCs
•KeySpan New York	•Niagara Mohawk
•KeySpan Long Island	•New York State Electric & Gas
•Consolidated Edison	•National Fuel Gas Distribution
•Orange & Rockland	•St. Lawrence Gas
•Central Hudson	•Rochester Gas & Electric